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THE LARAMIE PLAINS RED BEDS AND THEIR AGE.¹

THERE is not another formation in the entire Rocky Mountain region as conspicuous or as universal as the Red Beds. Go where you will, you find the strata of this dark red formation very near the base of the mountain ranges, often forming conspicuous hogbacks, and furnishing examples of wind erosion seldom if ever equaled. No formation in the arid west is so welcome to a geologist as he enters a field for the first time; for its lithological characteristics are so marked and uniform that it forms a horizon indicator that immediately furnishes a working basis.

From the days of the pioneer geologists in the Rocky Mountains, the majority have assigned the Red Beds to the Triassic. A few have been quite guarded in their opinions, and have given the matter unusual attention; but it has been the consensus of opinion that the formation was barren of fossils, and, since it was usually found above Coal-measures and below Jurassic, that it must be Triassic.

Hayden was the first geologist to publish anything in reference to the Laramie Plains. Unfortunately his observations were of the roughest reconnaissance type. In referring to the geology of the Laramie Mountains he says:²

East of the Big Laramie River, and along the western slope of the Laramie range, the entire series of unchanged rocks are visible, inclining at moderate angles, from the mountain sides. On the west side of this range the slope is more gentle, and the Carboniferous, Triassic, Jurassic, and Cretaceous beds present their upturned edges clearly to the scrutiny of the geologist.

The nucleus is red syenite for the most part, while from the margins

In referring to the structure of the same region, in the same report, he says:³

¹ Published by permission of the director of the United States Geological Survey.

² HAYDEN, *Second Annual Report*, p. 89.

³ *Ibid.*, p. 82.

incline, from either side, unchanged rocks belonging to the Carboniferous, Triassic, Jurassic, Cretaceous, and in some localities Tertiary.

In both of these references Hayden took it for granted that the Red Beds were Triassic.

The next important geological contribution to science in reference to the Laramie Plains Beds appears in the *Systematic Geological Report of the Fortieth Parallel Survey*, under the heading of "Triassic," pp. 249, 250, which reads as follows :

Directly overlying the Palæozoic limestones, in conformable superposition, and not infrequently overlapping the Palæozoic, and coming directly into nonconformable contact with the Archean, appear the well-known Rocky Mountain Red Beds, which, from their position between the Coal-measures below and the well-recognized Jurassic beds above, have been generally assigned to the Triassic age. Reserving all discussion of the validity of this assignment to later pages of this chapter, it is proposed here to give simply a brief statement of their physical condition and continuity along the flanks of Colorado Range within the field of this exploration. From the lower limit of the map nearly up to the forty-first parallel, the Red Beds lie directly upon the Archean, and form, with soft, friable strata, a remarkable contrast with the adjoining crystalline rocks, the red series varying in thickness from 300 to 850 feet. It is interesting to observe that where they are in direct contact with the Archean rocks they have a dip rarely exceeding 15 degrees, and often retaining an approximation to the horizontal ; while to the north, where erosion has been deep enough to reach and uncover the Palæozoic series, the dip increases to the vertical, with exceptional instances of slightly reversed position. The region of contact between the Trias and the Archean affords an interesting display of the mode of deposition of the coarse, friable gravel and sandy material of the Trias upon the hard irregularities of the crystalline series.

In the same chapter, pages 256-58, King refers to the Red Beds in the southern portion of the Laramie Plains as follows :

South of the railroad on the western side the contact of the Trias with the Archean is rather interesting. It is seen gradually to overlap the gentle inclinations in thin beds, and to abut squarely against the steeper slopes of the Archean. In general, it dips gently away from the Archean, the Trias ridges being defined by the harder beds which have protected from erosion the softer and more shaly portions below ; and wherever there are lines of erosion parallel to the contact-line with the Archean, the steeper or more escarped faces are turned toward the range.

Gypsum deposits are well shown north of the Willow Creek and the

North Park road, where they occur through a thickness of at least 80 or 100 feet, and are interstratified with dark, intensely red sandstones. South of the road are some remarkably eroded forms suggestive of ruined cities.

West of Antelope Creek the Trias extends twelve miles to the south of the Wyoming and Colorado boundary, filling a bay-like depression in the Archean body. Here are exposed, along the eastern side of Laramie Valley, 1,200 feet of beds having a very slight dip to the north and west, a high, abrupt wall of nearly 1,000 feet presented toward the plains. Upon the front of this escarped precipice may be seen the interstratified marls and limestones of the Jura, overlying the heavier red gypsiferous beds of the Trias. In contact with the Archean body the sandstones are of coarse, ash-colored materials containing angular fragments and rounded pebbles, with more or less calcareous matter in the cement, followed by a hard, thin, cherty limestone which passes up into reddish-gray sandstone, and above this the usual beds of coarse red sand, with numerous red clay beds, varying shaly, which give a prevailing argillaceous character to a wide zone of sandstone. Within this red argillaceous series are thin beds of pure clay and white gypsum, the latter varying from two or three inches up to several feet, with one solid body of twenty-two feet inclosed between two series of intensely red, dark, indurated sand-rock. Above the gypsiferous zone occur heavy red sandstones, which pass through yellowish friable beds with marly intercalations into the calcareous beds of the conformable Jura.

The following section illustrates the chief features of the Triassic series, as displayed here, beginning at the summit :

1. Yellowish-red sandstone, passing down into fine, deep-red, evenly bedded, strongly coherent sandstone - - - - - 375 to 400 feet.
2. Argillaceous shales and argillaceous sands, with interstratified layers of fine pure clay, the whole prevailing red, with grayish and yellowish-red zones carrying four or five beds of gypsum, one reaching twenty-two feet in thickness; in all 150 feet.
3. Red compact sandstones, beds of varying thickness, some coarser and some finer - - - - - 250 feet.
4. Reddish-gray sandstones carrying a bed of cherty limestone four or five feet thick; the whole - - - - - 175 feet.
5. Coarse, friable, ash-colored sandstones of remarkably loose texture, matrix containing more or less calcareous matter, with sheets of pebbles, partly rounded and partly angular cherty masses, together with some fragments of Archean schists, both hornblendic and granitoid - - - - - 150 to 200 feet.

There is no question but that King visited the Red Mountain area while making his survey; for there is no other place on the Laramie Plains where the Red Beds rise in nearly vertical walls upward of 500 feet. At the beginning of the chapter from which the above extracts were taken King states that he will

discuss the validity of the term "Triassic" as applied to the Red Beds at the close of the chapter, but I have failed to find his reference.

A portion of the Red Beds of the Laramie Plains occupies a belt of varying width along the western base of the Laramie Mountains. North of Laramie for a distance of forty miles the width varies from three to four miles, and the surface is gently rolling to within a short distance of the range, where there are now and then low hogbacks that have been cut with transverse gulches. South from Laramie the width gradually increases, and at Red Buttes is about six miles, and the eastern portion is marked with a great many eroded buttes which rise from 15 to 50 feet above the surface. Almost due south from Red Buttes there is a long, narrow spur of Archean rocks known as Boulder ridge, projecting into the valley country, causing the Red Beds to narrow down to about three miles. North and east of the Archean exposure there is a tongue-like mass of Red Beds extending into a depression in the Archean to the south of Tie Siding, and, if the width of the formation east and west is estimated from this place, it will be over twelve miles. Southward from Boulder Ridge the Red Beds widen rapidly toward the Colorado line, and near that place have an east and west expansion of about eighteen miles. In Colorado they form a narrow, V-shaped mass that occupies the angle at the intersection of the Laramie and Medicine Bow Mountains; but are nearly covered with Jurassic and Dakota formations.

Generally speaking, the topography of the Red Beds on the Laramie Plains is quite level or gently rolling. Occasionally the hogbacks are found near the ranges, and in three localities the surface is characterized by numerous buttes that have been worn into grotesque figures by wind erosion. These localities are Red Buttes, at the termination of Boulder Ridge and Sand Creek. In the latter place the wind-sculptured rocks are scattered along the valley for a distance of six miles, and present some of the most remarkable examples of wind erosion known in the state. The general forms are irregular domes of cross-

bedded red sandstone, which rise from 20 to 75 feet above the valley. These are occasionally consolidated into a wall with vertical sides, and this capped with grotesque figures altogether too complicated to admit of description here. The west winds cut notches, gaps, and in some places channels, to a depth of 20 or more feet. There are isolated, irregular towers that rise from 50 to 75 feet, and in some instances these have been nearly undermined by the greater erosion at their base, and in a few places they are found already tumbled to the ground. On Sand Creek, and on the Colorado-Wyoming line, Chimney Rock, with its curious rugged exterior, rises to a height of 350 feet above the stream that flows at its base.

The geological section that follows extends from the Archean mass east of Sand Creek, westward to and including Red Mountain, and has been constructed as follows: Nos. 1 to 44 inclusive, were measured on the eastern side of the formation. To the westward the gypsum and aragonite beds were found in the Payne ranch; but the thickness of the formation between the gypsum and No. 44 was not taken, nor were the Red Beds measured above the gypsum in this locality. Red Mountain has been faulted up so as to expose all of the Red Beds from below the gypsum beds upwards, and on account of the accessibility of this section the measurements from No. 44 upwards were taken at this point. The two sections have not been accurately put together, since it was impossible with limited time to locate the upper portion of the first part of the section at Red Mountain.

While at work during the last of November in the vicinity of Red Mountain, I discovered a fauna in the midst of the Red Beds, and to make its position clear I append the following section:

GEOLOGICAL SECTION.

	Feet.	Inches.
Archean granite, badly decomposed, base of Red Beds - -	10	0
1. Conglomerate, shading into coarse sandstone of a reddish-brown color - - - - -	1	6
2. Fine grained reddish conglomerate and sandstone - - -	17	0
3. Soft sandstone, shading from gray to red - - -	25	4
4. Whitish sandstone, with a few thin bands of red - - -	2	6

	Feet.	Inches.
5. Thin-bedded reddish and whitish sandstone - - - - -	1	6
6. Reddish argillaceous sandstone - - - - -	12	10
7. Whitish sandstone and conglomerate - - - - -	2	9
8. Soft, maroon-colored to whitish argillaceous sandstone - - - - -	1	5
9. Coarse light-gray sandstone - - - - -	0	9
10. Alternating bands of grayish to maroon-colored sandstone - - - - -	15	3
11. Mottled sandstone, red with greenish-white blotches - - - - -	3	9
12. Red shaly sandstone - - - - -	1	5
13. Drab calcareous sandstone - - - - -	1	2
14. Maroon-colored to light colored soft sandstone - - - - -	2	4
15. Reddish sandstone, with light-colored small circular patches - - - - -	0	7
16. Coarse-grained sandstone, very soft, mostly light-colored with red- dish streaks - - - - -	20	2
17. Coarse-grained sandstone, with a few bands of greenish-gray con- glomerate - - - - -	19	3
18. Dark-red sandstone, blotched with greenish gray - - - - -	3	3
19. Fine-grained conglomerate, grayish, with cross-bedded red strata - - - - -	2	9
20. Reddish conglomerate, cross-bedded with many angular frag- ments - - - - -	26	4
21. Red sandstone and fine-grained conglomerate with whitish bands, only partially exposed - - - - -	27	1
22. Dark gray to brown sandstone - - - - -	1	6
23. Maroon-colored to whitish, soft, thin-bedded sandstone - - - - -	37	11
24. Red shaly sandstone - - - - -	3	8
25. Red and whitish cross-bedded sandstone - - - - -	13	5
26. Red sandstone, with pebbles at base - - - - -	4	0
27. Fine-grained cross-bedded conglomerate - - - - -	3	10
28. Red to gray sandstone, evenly bedded, with large fragments of plant(?) remains. These are found to lie conformable to the bed- ding plains, and are from two to four inches in diameter and often several feet in length - - - - -	21	5
29. Red sandstone, rather hard - - - - -	9	0
30. Red coarse-grained cross-bedded sandstone, with flint nodules and grayish-green patches - - - - -	11	0
31. Red sandstone - - - - -	9	7
32. Red to brownish sandstone, with a few lighter-colored streaks - - - - -	19	8
33. Red sandstone, with drab particles near the top - - - - -	4	2
34. Coarse-grained cross-bedded red sandstone - - - - -	6	2
35. Dark red sandstone, with light-colored streak - - - - -	12	4
36. Red to gray cross-bedded sandstone - - - - -	2	3
37. Fine-grained light sandstone - - - - -	2	7
38. Coarse red sandstone and conglomerate - - - - -	10	5
39. Dark red sandstone, rather hard, and in strata varying from 8 to 22 inches in thickness - - - - -	15	8
40. Shelly drab limestone - - - - -	2	2

	Feet.	Inches.
41. Brick-red sandstone, massive and thick bedded at base; changing to exceedingly cross-bedded structure above. This band weathers into the most peculiar wind-carved figures, which are so common along Sand Creek, where there are several hundred of them. The usual form is a dome, but there are columns, spires, arches, and figures altogether too numerous to refer to here. In reality this band weathers with a peculiar topography which can be easily traced	51	7
42. Whitish and red shaly sandstone, light bands alternating with the red	61	8
43. Red shaly sandstone, capped with 2 feet of hard red sandstone	34	7
44. Red sandstone, mottled with grayish-green blotches. The surface talus covered, and detailed measurements could not be made	151	8
There is an interval at this point in the section that has not been measured; but the thickness is of slight importance and will not amount to 50 feet.		
45. Red sandstone	15	0
46. Greenish to gray soft sandstone	20	0
47. Grayish to reddish sandstone, containing the following genera of fossils: <i>Allorisma</i> , <i>Pleurophorus</i> , <i>Bellerophon</i> , <i>Myallina</i> , <i>Aviculopecten</i> , <i>Dentalium</i> (?), <i>Pleurotomaria</i> (?), several small gasteropods, and some remains of vertebrates	1 to 4	0
48. Gypsum bed, excellent quality	50	0
49. Red clay and gypsum strata alternating, and one of the clay bands containing innumerable aragonites (pseudomorphs after hanksite)	20	0
50. Red sandstone and shale	100	
51. Gray wavy-bedded quartzite	3 to 5	0
52. Red sandstone and shales. Light red and shaly at base; heavy bedded and dark maroon-colored near the top, with no change in general coloration	675	0
Total	1,578	2

Measurements from 45 to 52, inclusive, are subject to revision.

The genera referred to in No. 47 are so characteristic that it is not necessary to discuss their geological position; they belong to the Palæozoic, and resemble to a marked degree the fossils of the Kansas and Nebraska Permian. This places all of the strata below the fossiliferous band in the Palæozoic. There remains a formation of about eight hundred feet in thickness, with the gypsum beds at its base in a questionable position, and some may wish to retain these beds in the Triassic.

All of the pioneer geologists who studied the Laramie Plains

commented on the Red Beds resting on the Archean south of the Union Pacific railroad, and also upon the conformable contact of the Red Beds and the limestones further northward. From my recent investigation I have found that the limestones shade almost imperceptibly into the red sandstones, and that the strata of the lower portion of the Red Beds are identical with the strata of limestones to the northward, the difference in the lithological characteristics being due to the varied physical conditions during sedimentation. Here is a very peculiar instance where rocks of the same age, and, in fact, identical strata, have been differentiated on purely lithological grounds. Just what proportion of the Red Beds will be equivalent to the limestones has not been determined; but probably not less than five hundred feet of the strata near the Colorado line will correspond to limestones and light-colored sandstones some fifteen or twenty miles to the northward, and possibly a greater thickness.

From the data in hand it will be observed that physical conditions favoring the deposition of Red Beds had been in existence for a long time prior to the forming of the fossiliferous band containing the Palæozoic fossils. Above the fossiliferous horizon the formation is made up of the same, or similar, red sandstones and shales; but it is more uniform in color and persistent in its lithological characteristics, and to the northward these strata do not merge into limestones. On the other hand, the Red Beds are conformable throughout, and there is no line of demarkation discovered thus far that would act as a basis of subdivision. There are a few beds of gypsum and limestone, but these are not persistent enough to be utilized as boundary lines. For the above reasons I am in favor of placing the Red Beds in the Palæozoic.

From a palæontological standpoint, likewise, it seems advisable to refer the Red Beds to the Palæozoic. The fauna referred to is purely Palæozoic, and without the slightest evidence of Mesozoic types. It would be unreasonable to expect that a Mesozoic fauna could have developed from the one referred to

in No. 47 in the little time required to have accumulated eight hundred feet of gypsum and sandstone. I realize that this is based purely upon theory; but nevertheless it seems advisable at this time to offer this suggestion. If adopted, it will deprive the eastern Rocky Mountain region of the term "Triassic," and make the basal member of the Mesozoic the Jurassic. Further west, especially along the flanks of the Wasatch Mountains, there are undoubted Triassic beds.

A second question to settle will be the position of these Red Beds in the Palæozoic. Already the limestones along the Laramie Mountains have been referred to the Upper Carboniferous by several geologists; but upon very slight palæontological evidence. None of the early investigators were able to find many fossiliferous bands. In recent years I have found quite a fauna in the limestones, and this resembles the Kansas and Nebraska fauna of the Permian. The fossiliferous bands are near the top of the formation, and there may be typical Coal-measure fossils below; but such have not been discovered, and I am inclined to believe that the limestones of the Laramie Mountains correspond very nearly with the Permian of the Missouri Valley. The Red Beds merge into the limestones or rest conformably upon them, and here we have conditions very similar to those that have been recently discussed from southern Kansas and to the southward. From our present knowledge, it seems advisable to refer the Red Beds of the Laramie Plains to the Permian. This classification has been suggested to me before. Only a few years ago Dr. Williston, while making me a visit, remarked: "Why do you not place the Red Beds in the Permian?" I stated "that we had never been able to discover any fossil remains to guide us in identifying them as Permian." At the time he advanced the idea that the Red Beds in Wyoming were very much like the Red Beds of Kansas.

Further evidence concerning the fossils may be looked for, and I believe that many more localities will be found where fossils have been preserved that will materially aid in the future work. The finding of vertebrate remains is also of importance.

The bones found are so fragmentary as to be beyond identification; but further search will, beyond question, yield better results. The invertebrates have been placed in the hands of Dr. Girty, of the United States Geological Survey, for study, and as soon as he has finished his work there will be a joint paper published that will consider the limestones as well as the Red Beds of the Laramie Plains and their geological position.

WILBUR C. KNIGHT.

UNIVERSITY OF WYOMING,
March 18, 1902.